INDOOR AIR QUALITY ASSESSMENT

Hale Middle School
55 Hartley Road
Stow, MA

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
October 2004

Background/Introduction

At the request of the Nashoba Regional School District (NRSD), the Massachusetts Department of Public Health (MDPH), Center for Environmental Health's (CEH) Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality at Hale Middle School (HMS), 55 Hartley Road, Stow, Massachusetts. Concerns about indoor air quality symptoms related to potential mold growth, particularly in lower level classrooms, prompted the request.

On June 3 2004, a visit to conduct an indoor air quality assessment was made to this school by Cory Holmes, an Environmental Analyst in BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program. Mr. Holmes was accompanied by Jim Ducharme, Facility Manager, NRSD, Joan Cutting, School Nurse and John Wallace, Health Agent, Stow Board of Health.

The HMS is a multi-level (lower, main and upper), red brick on slab building constructed in 1965. The building underwent renovations from 1995-1996. The school contains general classrooms, science classrooms, gymnasium, library, kitchen/cafeteria, auditorium, chorus and band rooms, computer labs, consumer science rooms, technological education and office space. Windows are openable throughout the building.

The building has a history of water penetrating through the building envelope in lower level classrooms, primarily corner classroom 102. In August of 2003, the NRSD contracted with Covino Environmental Associates, Inc. (Covino), an environmental consultant, to conduct bioaerosol monitoring. Covino reported that no further remedial actions were warranted (Covino, 2003). However, they did recommend that the mechanical ventilation system servicing the lower level be evaluated by an HVAC engineering firm to ensure proper humidity control (Covino, 2003).

In December of 2003, the NRSD contracted with Touchstone Environmental Consultants, Inc. (Touchstone) to conduct further microbial testing. Touchstone recommended that in the absence of continued occupant complaints, no further testing be conducted. However, as preventative measures, Touchstone recommended: 1) inspecting and cleaning the interior of the univent in classroom 102; 2) cleaning and maintaining dehumidification units routinely; 3) cleaning and disinfecting the closet walls, floor and slop sink in the custodial closet routinely; 3) prohibiting the long-term storage of damp, dirty or odorous cleaning materials; and 4) reviewing the schedule and volume of the custodial closet exhaust fan (Touchstone, 2003).

Methods

BEHA staff performed a visual inspection of building materials for water damage and/or microbial growth. Moisture content of building materials was measured with a Delmhorst, BD-2000 Model, Moisture Detector with a Delmhorst Standard Probe. Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID).

Results

The HMS houses approximately 285 sixth through eighth grade students and approximately 45 staff members. The tests were taken during normal operations at the school. Test results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were above 800 parts per million (ppm) in five of twenty-one areas, indicating adequate ventilation in the majority of areas surveyed. Temperature and airflow is controlled by a centralized computer system. Fresh air in classrooms is mechanically supplied by a unit ventilator (univent) system (Figure 1). Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building (Picture 1) and return air through an air intake located at the base of each unit. Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit. Univents are equipped with control settings of low, medium or high (Picture 2). The majority of univents were operating during the assessment; however, some univents had been deactivated (Table 1). Obstructions to airflow, such as items on top of univents and items in front of univent returns were also seen in a number of classrooms (Picture 3). To function as designed, univents must be activated and allowed to operate. Importantly, univent air diffusers and univent returns must remain free of obstructions.

Mechanical exhaust ventilation is provided by ceiling or wall-mounted vents powered by rooftop fans. The exhaust system was either not functioning or drawing weakly in several areas surveyed (Table 1), indicating that motors were deactivated or non-functional. Exhaust vents were obstructed in some areas (Picture 4). As with the univents, exhaust vents must be activated and remain free of obstructions in order to function as designed. Without sufficient supply and exhaust ventilation, environmental pollutants can build up, leading to indoor air quality complaints.

Mechanical ventilation for common areas (gymnasium, auditorium, cafeteria, etc) is provided by air-handling units (AHUs), which are located on the roof (Picture 5) or in mechanical rooms. Air is provided through wall or ceiling-mounted vents and ducted back to AHUs via ceiling or wall-mounted return grills. These systems were operating during the assessment.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of occupancy. In order to have proper ventilation with a mechanical ventilation system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last systems balancing reportedly occurred in 1996, when building renovations were completed.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 ppm. Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, see Appendix A.

Temperature measurements ranged from 70^{o} F to 81^{o} F, which were above the BEHA recommended comfort range in several areas (Table 1). The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. Heat/temperature control complaints were reported in second floor classrooms. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. In addition, it is difficult to control temperature and maintain comfort without operating the ventilation equipment as designed (e.g., univents and exhaust vents deactivated/obstructed).

The relative humidity measured in the building ranged from 37 to 51 percent, which were within or close to the lower level of the BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States. Temperature and humidity control issues were reported in the inner computer room located within the technology education room. BEHA staff noted the door between the inner computer room and technology education room was open while the air conditioning units were operating (Picture 6). In order to maintain comfort and relative humidity in the computer room, the door should be closed.

Microbial/Moisture Concerns

As discussed, the building has a history of water penetrating through the building envelope due to poor drainage, specifically outside of corner classroom 102. To prevent further water damage the NRSD has taken several measures to improve drainage:

- Installed a drainage system and catch basin (Picture 7);
- Re-graded the land outside of this area of the building to direct water toward the drain; and

- Installed a tarmac against the exterior wall to facilitate water flow toward the drain (Picture 8).

In addition, all water damaged building materials (gypsum wallboard, insulation, etc.) in affected areas were reportedly replaced.

In order for building materials to support mold growth, a source of moisture is necessary. Identification and elimination of water moistening building materials is necessary to control mold growth. Building materials with increased moisture content over normal concentrations may indicate the possible presence of mold growth. Identification of the location of materials with increased moisture levels can also provide clues concerning the source of water supporting mold growth.

In an effort to ascertain moisture content of building materials in this area, readings were taken in materials that would most likely be impacted by water penetration. Building materials tested included ceiling tiles and gypsum wallboard near exterior walls/windows. Moisture readings from similar building materials located on interior walls were measured for comparison. The Delmhorst probe is equipped with three lights as visual aids to determine moisture level. Readings that activate the green light indicate a sufficiently dry or low moisture level, those that activate the yellow light indicate borderline conditions and those that activate the red light indicate elevated moisture content. No elevated moisture readings were measured during the assessment.

The building is equipped with gutters and downspouts to drain rainwater away from the building. The gutter system in the rear of the building was damaged, causing water to splash against the building (Pictures 9 and 10). Excessive exposure of exterior brickwork to water can result in damage over time. During winter weather, the freezing and thawing of moisture in bricks can accelerate the deterioration of brickwork. Damaged brickwork can result in water intrusion.

Active roof leaks were reported and water damaged ceiling tiles were observed in several areas of the building (Table 1/Picture 11). At the time of the assessment, school officials reported that they were working with a roofing contractor to repair faulty flashing. Water-damaged ceiling tiles can provide a source of mold and should be replaced after a water leak is discovered and repaired. In addition, several roof drains were noted to be clogged with pine needles and debris, which can lead to water pooling and potential roof leaks (Picture 12). The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Water-damaged porous materials cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy porous materials is not recommended.

Dehumidifiers were in operation in lower level classrooms. To provide continuous drainage and prevent standing water, the reservoirs of dehumidifiers were being mechanically pumped into the slop-sink in the custodial closet. However, in order for the water to drain into the slop-sink it has to be pumped vertically 8-10 feet above the ceiling tile system, through the hallway and down into the custodial closet (Pictures 13-15). Although this system appeared to be working in the majority of areas (the dehumidifier in the language room was not operating), the opportunity for mechanical pumps to malfunction exists. Most of the lower level classrooms are equipped with sinks. BEHA staff recommended that dehumidifiers be stationed on sink countertops to allow hoses to drain directly into sinks.

Other Concerns

Indoor air quality can be negatively influenced by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion emissions include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, BEHA staff obtained measurements for carbon monoxide and PM2.5.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address airborne pollutants and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from 6 criteria pollutants, including carbon monoxide and particulate matter. As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the US EPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Outdoor carbon monoxide concentrations were non-detectable or ND (Table 1). Carbon monoxide levels measured in the school were also ND.

As previously mentioned, the US EPA also established NAAQS for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits to particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 microgram per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2000a). These standards were adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, the US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM2.5 standards requires outdoor air particle levels be maintained below 65 $\mu g/m^3$ over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, BEHA uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment. Outdoor PM2.5 concentrations were measured at 5 $\mu g/m^3$ at the time of the assessment. Indoor PM2.5 levels ranged from 5-16 $\mu g/m^3$ (Table 1). Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulates during normal operation. Sources of indoor airborne particulate may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices, operating an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be negatively influenced by the presence of materials containing volatile organic compounds (VOCs). VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. An outdoor air sample was taken for comparison. Outdoor TVOC concentrations were ND. Indoor TVOC concentrations were also ND (Table 1).

Please note, that the TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use of TVOC containing products. While TVOC levels were ND, materials containing VOCs were present in the school. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat. Cleaning products were found on countertops and beneath sinks in a number of classrooms. Cleaning products contain chemicals, which can be irritating to the eyes, nose and throat and should be stored properly and kept out of reach of students.

Several other conditions that can affect indoor air quality were seen during the assessment. Accumulated dust was observed on classroom exhaust vents (Picture 16). Exhaust vents should be cleaned periodically to avoid aerosolizing accumulated dust. Also of note was the amount of materials stored inside some classrooms (Picture 17). Items were observed on windowsills, tabletops, counters and bookcases. The large number of items stored provides a source for dusts to accumulate and make it difficult for custodial staff to clean. Airborne dust can be irritating to eyes, nose and respiratory tract. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up.

Finally, an air purifier was seen in one classroom. These units are equipped with filters that should be cleaned/changed as per manufacturer's instructions. Without cleaning/changing filters, the activation of these units can re-aerosolize dirt, dust and particulates, which can be irritating to certain individuals.

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Consider consulting a heating,

ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers.

2. Operate all ventilation systems that are operable throughout the building (e.g., gym, auditorium, classrooms) continuously during periods of school occupancy and independent of thermostat control. To increase airflow in classrooms, set univent controls to “high”.
3. Inspect exhaust motors and belts for proper function. Repair and replace as necessary.
4. Remove all blockages from univents and exhaust vents to ensure adequate airflow.
5. Develop a notification system for building occupants to report ventilation/comfort complaints.
6. Contact the school’s HVAC consultant to determine further enhancement. Monitor HVAC equipment for proper function and temperature control, primarily on the second floor.
7. Consider adopting a balancing schedule of every 5 years for mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
8. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (e.g., throat and sinus irritations).

9. Continue with plans to make roof/flashing repairs. Once leaks are repaired, replace water damaged ceiling tiles. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
10. Repair gutter system to prevent backsplash against the building.
11. Consider placing dehumidifiers on sink countertops to allow drainage directly into sinks. Clean and maintain dehumidifiers as per the manufactures instructions.
12. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
13. Clean exhaust/return vents periodically to prevent excessive dust build-up.
14. Clean/change filters for portable air purifiers as per manufacturer's instructions or more frequently if needed.
15. Consult "Mold Remediation in Schools and Commercial Buildings" published by the US EPA (2001) for further information on mold. Copies of this document can be downloaded from the US EPA website at: http://www.epa.gov/iaq/molds/mold_remediation.html.
16. Consider adopting the US EPA (2000b) document, "Tools for Schools", in order to maintain a good indoor air quality environment on the building. This document can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.
17. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

References

ACGIH. 1989. Guidelines for the Assessment of Bioaerosols in the Indoor Environment. Code Administrators International, Inc., Country Club Hill, IL.

ASHRAE. 1989. Ventilation for Acceptable Indoor Air Quality. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 62-1989

BOCA. 1993. The BOCA National Mechanical Code/1993. 8th ed. Building Officials and Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

Covino. 2003. Covino Environmental Associates, Inc. Covino Project 03.00762, Bioaerosol Monitoring, Hale Middle School. August 6, 2003.

MDPH. 1997. Requirements to Maintain Air Quality in Indoor Skating Rinks (State Sanitary Code, Chapter XI). 105 CMR 675.000. Massachusetts Department of Public Health, Boston, MA.

OSHA. 1997. Limits for Air Contaminants. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

Sanford. 1999. Material Safety Data Sheet (MSDS No: 198-17). Expo® Dry Erase Markers Bullet, Chisel, and Ultra Fine Tip. Sanford Corporation. Bellwood, IL.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0.

SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning

Touchstone. 2003. Touchstone Environmental Consultants, Inc. Air Quality Baseline, Hale Middle School, Stow, MA. December, 29, 2003.

US EPA. 2000a. National Ambient Air Quality Standards (NAAQS). . US Environmental Protection Agency, Office of Air Quality Planning and Standards, Washington, DC. http://www.epa.gov/air/criteria.html.

US EPA. 2000b. Tools for Schools. Office of Air and Radiation, Office of Radiation and Indoor Air, Indoor Environments Division (6609J). EPA 402-K-95-001, Second Edition. http://www.epa.gov/iaq/schools/tools4s2.html

US EPA. 2001. "Mold Remediation in Schools and Commercial Buildings". Office of Air and Radiation, Indoor Environments Division, Washington, DC. EPA 402-K-01-001. March 2001. Available at: http://www.epa.gov/iaq/molds/mold_remediation.html

Picture 1

Univent Air Intake

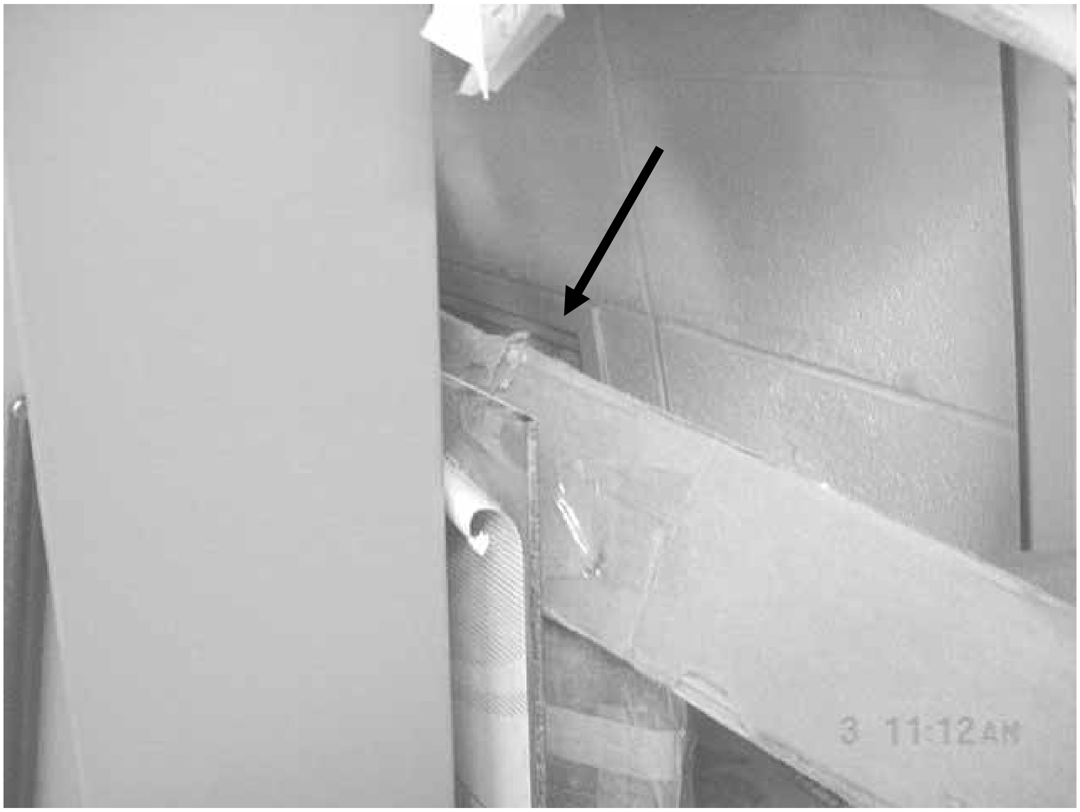
Picture 2

Univent Fan Speed Control

Picture 3

Classroom Items on Univent Air Diffuser

Picture 4



Obstructed Exhaust Vent in Tech. Ed Room

Picture 5

Rooftop AHU

Picture 6

Open Door between Computer Room and Technology Education Room

Picture 7

Drain Installed Outside of Corner Classroom 102

Picture 8

Grading of Land and Tarmac Installed Outside Corner Classroom 102

Picture 9

Damaged Gutter/Downspout outside Classroom 102

Picture 10

Characteristic Backsplash Stain against Building

Picture 11

Water Damaged Ceiling Tiles

Picture 12

Clogged Roof Drain and Water Pooling on Lower Roof

Picture 13

Drainage Tube

Dehumidifier in Lower Level Classroom with Pump and Drainage Vertical Tube

Picture 14

Dehumidifier Drainage Tube Into/Over Ceiling Tile System

Picture 15

Dehumidifier Drainage Tubes Draining into Slop-Sink in Custodial Closet

Picture 16

Accumulated Dust Build-up on Exhaust/Return Vent

Picture 17

Accumulated Items on Flat Surfaces in Art Classroom

Hale Middle School | **Indoor Air Results**

55 Hartley Road, Stow MA 01775 | **June 3, 2004**

Table 1

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Background (Outdoors)	70	41	363	ND	ND	5		-	-	-	Atmospheric conditions: clear, sunshine, winds light and variable
101	71	48	520	ND	ND	7	1		Y wall	Y ceiling	DEM
203	70	50	530	ND	ND	6	0	Y	Y off univent	Y off wall	DEM, UV –off reactivated by Mr. Ducharme, exhaust vent-dusty, DEM
104	73	51	754	ND	ND	5	2	N	Y wall	Y off wall	Dehumidifier mechanically pumped vertically above ceiling plenum into custodial closet floor drain, AP
102	76	47	988	ND	ND	5	8	Y	Y univent	Y wall	CP, DEM, dehumidifier
313	77	37	780	ND	ND	9	15	Y	Y univent	Y ceiling	DEM, PF, 2 windows open
208	79	45	1061	ND	ND	12	21	Y	Y univent	Y wall	DEM, nests, fur/pelts

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile

NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings

sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WD = water-damaged
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

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Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
308	81	50	1208	ND	ND	12	19	Y	Y Ceiling	Y Wall	DEM, hallway door open; UV blocked by clutter, 2 WD-CT
310	80	40	871	ND	ND	8	18	Y	Y Ceiling	Y off Wall	Clutter, 7 WD CT
Music Room	75	43	497	ND	ND	8	2	Y	Y Ceiling	Y Ceiling	DEM, 2 windows open
Library	72	42	474	ND	ND	7	3	Y	Y Ceiling	Y Ceiling	
Teacher's Room	74	40	479	ND	ND	12	0	Y	Y Ceiling	Y Ceiling	Hallway DO
Chorus	72	43	430	ND	ND	7	0	Y	Y univent	Y Ceiling	DEM
202	76	39	511	ND	ND	8	1	Y	Y univent	Y off wall	DEM, 10 occupants gone 20 min, UV deactivated

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									Supply	Exhaust	
204	77	42	737	ND	ND	8	20	Y	Y univent	Y wall	4 windows open, DEM, hallway DO, 3 WD CT
205	75	42	541	ND	ND	11	0	Y	Y univent	Y off wall	DEM, clutter, UV and exhaust vents obstructed by clutter, DEM, vented kiln
207	78	44	1175	ND	ND	16	24	Y	Y univent	Y wall	DEM, hallway door open;
304	75	45	500	ND	ND	9	0	Y			Occupants at lunch, 4 WD CT, 3 windows open
Tech Ed	72	50	676	ND	ND	5	2	Y	Y ceiling	Y wall	DEM, exhaust vent obstructed by clutter, hallway DO,
Computer Room (Tech Ed)	72	49	633	ND	ND	5	1	N	Y ceiling	Y wall	Inter-room DO, recommend shutting interior computer room door during AC season, DEM
Gym	73	44	590	ND	ND	6	0	N	Y ceiling	Y wall	

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Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Health	73	40	485	ND	ND	6	3	N	Y ceiling	Y ceiling	Inter-room DO

ppm = parts per million	AT = ajar ceiling tile	design = proximity to door	NC = non-carpeted	sci. chem. = science chemicals
µg/m3 = micrograms per cubic meter	BD = backdraft	FC = food container	ND = non detect	TB = tennis balls
	CD = chalk dust	G = gravity	PC = photocopier	terra. = terrarium
AD = air deodorizer	CP = ceiling plaster	GW = gypsum wallboard	PF = personal fan	UF = upholstered furniture
AP = air purifier	CT = ceiling tile	M = mechanical	plug-in = plug-in air freshener	WD = water-damaged
aqua. = aquarium	DEM = dry erase materials	MT = missing ceiling tile	PS = pencil shavings	WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%